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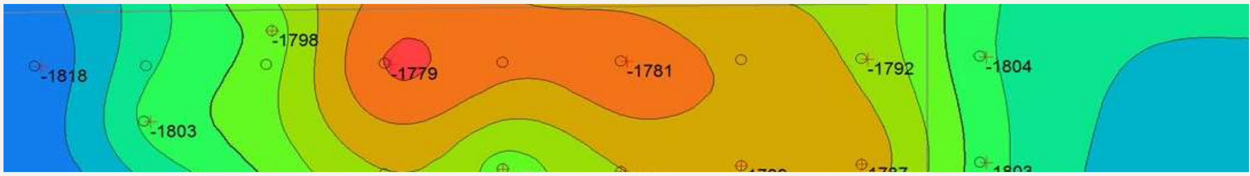

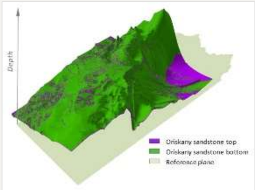

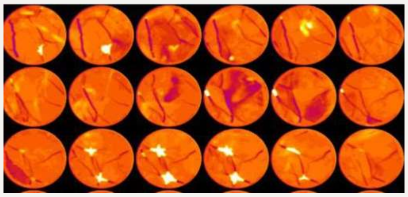

Cognac Offshore Oil Field Case Study

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Disclaimer

Cognac Offshore Oil Field Case Study

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LIST OF EXHIBITS

ACRONYMS AND ABBREVIATIONS

ϕ	Reservoir porosity
A	Accessible Oil Area (acres)
2-D	Two dimensional
3-D	Three dimensional
API	American Petroleum Institute
ARI	Advanced Resources International
bbl/d	Barrels per day
Bcf	Billion cubic feet
CO_2	Carbon dioxide
DOE	Department of Energy
DP	Dykstra-Parsons
EOR	Enhanced oil recovery
F	Net payzone thickness (feet)
ft	Foot, feet
ft^2	Square feet
GOM	Gulf of Mexico
Mbbl	Thousand barrels
MC 194	Cognac deepwater oilfield
Mcf/bbl	Thousand cubic feet per barrel
mD	Millidarcy
MESA	Mission Execution and Strategic Analysis
MMbbl(s)	Million barrels
MMcf	Million cubic feet
MMcfd	Million cubic feet per day
N/A	Not applicable
NE	Northeast
NETL	National Energy Technology Laboratory
OCS	Outer continental shelf
OOIP	Original oil in place
psi	Pounds per square inch
psia	Pounds per square inch absolute
rb	Reservoir barrel
stb	Stock tank barrel
Soi	Initial oil saturation
Swi	Initial water saturation
U.S.	United States
°F	Degrees Fahrenheit

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1 INTRODUCTION

Offshore Gulf of Mexico (GOM) outer continental shelf (OCS) oil fields offer significant potential for storage of captured carbon dioxide (CO_2) emissions and incremental oil production using CO_2 enhanced oil recovery (EOR). Understanding the scope and potential of these resources requires in-depth analysis of offshore oil field geologic settings and projects costs. The National Energy Technology Laboratory (NETL) has developed a robust set of onshore CO_2 EOR modeling tools (e.g., the Fossil Energy/NETL CO_2 Prophet Model [CO_2 Prophet Model]), [1] [2] which may be adaptable for modeling offshore CO_2 EOR resources and projects costs. However, developing a set of offshore CO_2 EOR modeling tools requires significant understanding of offshore reservoir characteristics, oil field infrastructure, and project economics. Therefore, it is important to develop a knowledge base of GOM OCS offshore oil reservoir geology and understand the challenges of offshore oil field development and operation in greater detail. Given that the overall offshore CO_2 EOR concept is in its infancy, there is very little field data available to inform model development.

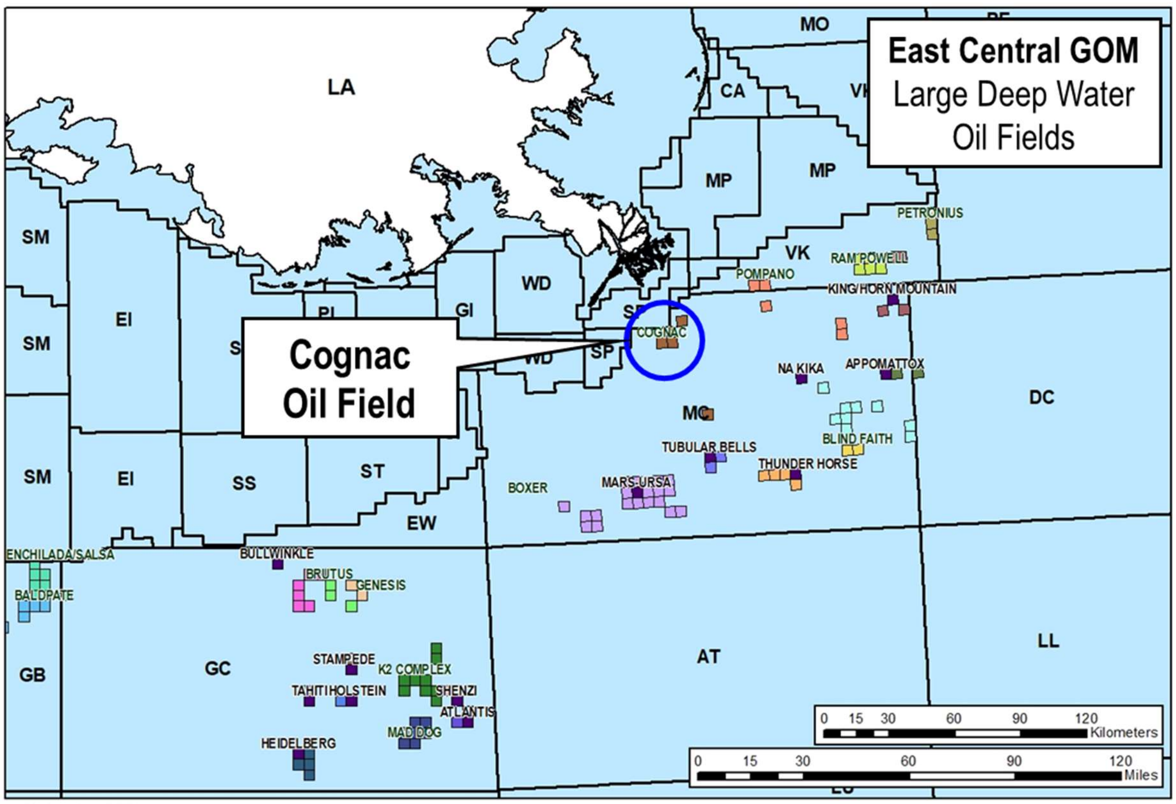
For this study, a small subset of GOM OCS offshore oil fields were investigated and then case studies on the Cognac oil field (discussed in this report) and Petronius oil field [3] were conducted to generate a body of knowledge on the potential offshore CO_2 EOR concept, so that models with the ability to reliably replicate potential offshore CO_2 EOR operations can later be developed. The primary purpose of this study is to assess to what extent the CO_2 Prophet Model is able to reasonably represent the performance of an offshore CO_2 flood, including appropriately capturing the geologic complexity and irregular well spacings typical of offshore oil fields. To perform the assessment of the capabilities of the CO_2 Prophet Model, the following seven tasks were completed:

1. Built a representative geologic model for the Cognac oil field J Sand, including capturing its structural setting and associated aquifer
2. Assembled the key reservoir properties of the J Sand, including its volumetric data, fluid flow capabilities (including relative permeability curves), and oil composition to construct a reservoir model
3. Established the locations of the existing oil/gas production wells in the J Sand
4. Used Computer Modelling Group Ltd.'s GEM compositional simulator ("GEM") to provide a "first-order" history match of fluid production from the J Sand and to calibrate the J Sand's geologic and reservoir description with its oil, gas, and water production history
5. Appraised the performance of a post-primary CO_2 EOR project in the J Sand using GEM with a calibrated geologic/reservoir description
6. Appraised the performance of a post-primary CO_2 EOR project in the J Sand using the CO_2 Prophet Model (a variant of the NETL CO_2 Prophet Model with similar functionality and performance analysis) in parallel with GEM
7. Compared the modeling results of a post-primary CO_2 EOR project in the Cognac oil field J Sand from GEM and the CO_2 Prophet Model to determine whether the CO_2 Prophet Model could reasonably represent the performance of the CO_2 flood compared to the more sophisticated GEM

2 COGNAC OIL FIELD

The Cognac deepwater oil field (MC 194) is located in 1,022 feet (ft) of water in the East Central GOM (Exhibit 2-1). [4] The Cognac oil field, with 184 million barrels (MMbbl) of original oil reserves and 762 billion cubic feet (Bcf) of original gas reserves, essentially produced all of its reserves as of the end of 2017. Oil production that peaked at 83,000 barrels per day (bbl/d) of oil and 128 million cubic feet per day (MMcfd) of gas in 1983 declined to about 2,000 bbl/d of oil in 2016, placing the Cognac oil field on a list of oil fields facing near-term abandonment.

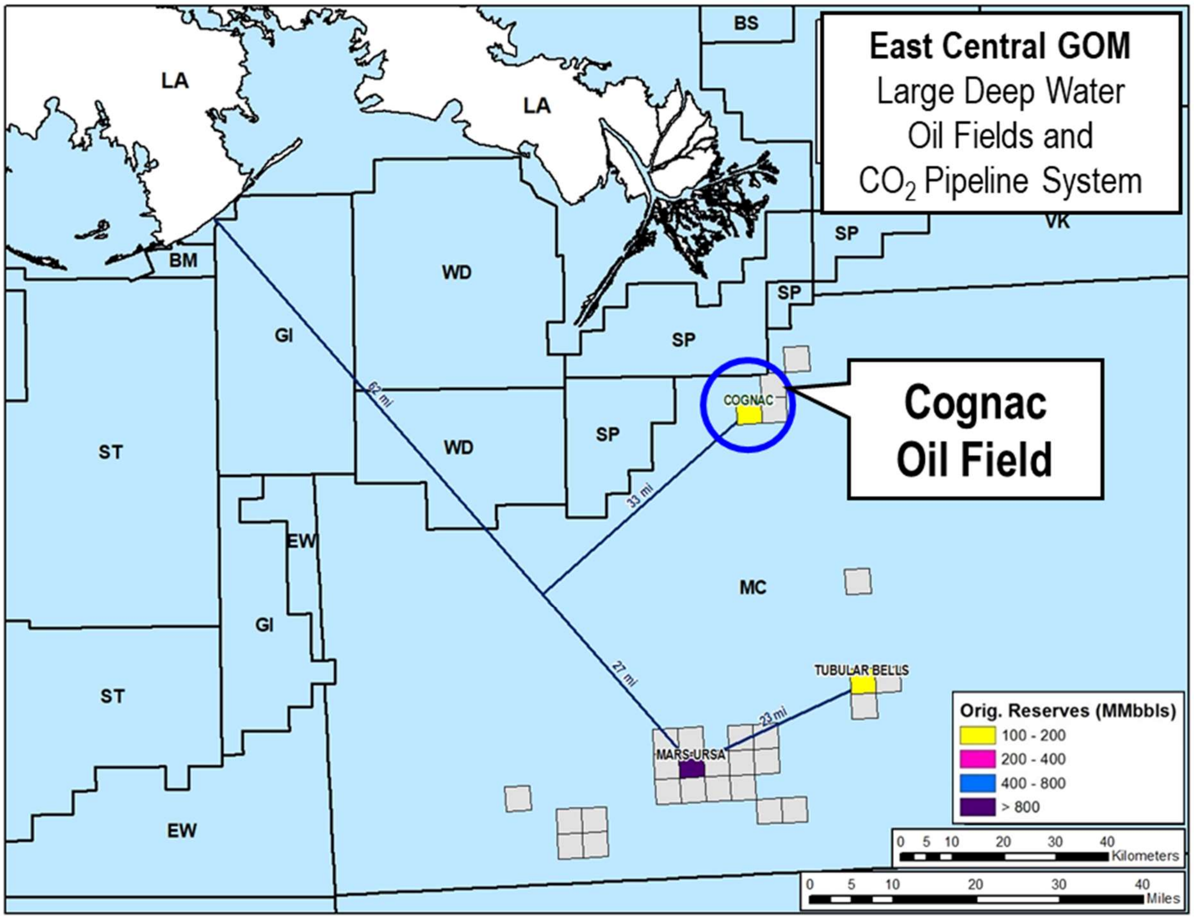
Exhibit 2-1. Location of Cognac oil field, East Central GOM



When installed in 1978, the Cognac platform set a host of deepwater platform records for the GOM. At 1,022 ft deep, its installation marked the first time industry had placed a platform in water depths greater than 1,000 ft. Recognizing the innovative design of the Cognac platform, the American Society of Civil Engineers presented Shell, the operator of the field, with the Outstanding Civil Engineering Achievement award. [5]

The Cognac oil field covers parts of four offshore blocks (MS 194, MS 195, MS 150, and MS 151). To define the areal extent of the Cognac oil field and its productive sands, 2 semisubmersible rigs drilled 12 expendable oil field delineation wells. Exhibit 2-2 illustrates how a regional offshore CO_2 pipeline system could connect the Cognac oil field to CO_2 supplies from onshore Louisiana enabling the oil field to pursue CO_2 EOR and store CO_2. [4]

Exhibit 2-2. Potential CO_2 pipeline system for Cognac oil field, East Central GOM



2.1 STRUCTURAL SETTING

The Lower Pleistocene to Upper Pliocene Cognac oil field is associated with a major faulted, nose plunging salt feature. The entire structure is downthrown to an east to west dipping growth fault. Fault A-1 is the major updip trapping fault. Additional faults, some of which are sealing, add complexity to the oil field. [6]

2.2 COGNAC OIL RESOURCES

The Cognac oil field contains two major sands, the I Sand and the J Sand, as well as the smaller J-1 Sand and other sands (Exhibit 2-3). The J Sand, the second largest sand in the Cognac oil field, holds 136 MMbbl of original oil in place (OOIP) and an expected recovery efficiency (from primary depletion supported by a strong bottom waterdrive) of 40 percent, providing a reasonable size of remaining oil saturation and resource target. The larger I Sand, with 191 MMbbl of OOIP, has a somewhat higher expected oil recovery efficiency of 48 percent, providing a smaller remaining oil saturation target. The J-1 Sand, with 23 MMbbl of OOIP, as well as a series of smaller sands are considered to be too small for an economically viable CO_2 flood. [4]

Exhibit 2-3. Cognac oil resources, cumulative production, and remaining reserves

Sands	Oil Area (Acres)	OOIP (MMbbl)	Cumulative Oil Production[A] (MMbbl)	Remaining Oil Reserves[A] (MMbbl)
Major Sands				
I	3,560	191.5	91.7	0.1
J	2,240	135.6	56.9	0.3
Minor Sands				
J-1	1,740	23.3	6.6	N/A[B]
Others	N/A	N/A	16.0	3.2
Total	**7,540**	**350.4**	**171.2**	**3.6**

[A]As of end of 2016
[B]Less than 0.05 MMbbl

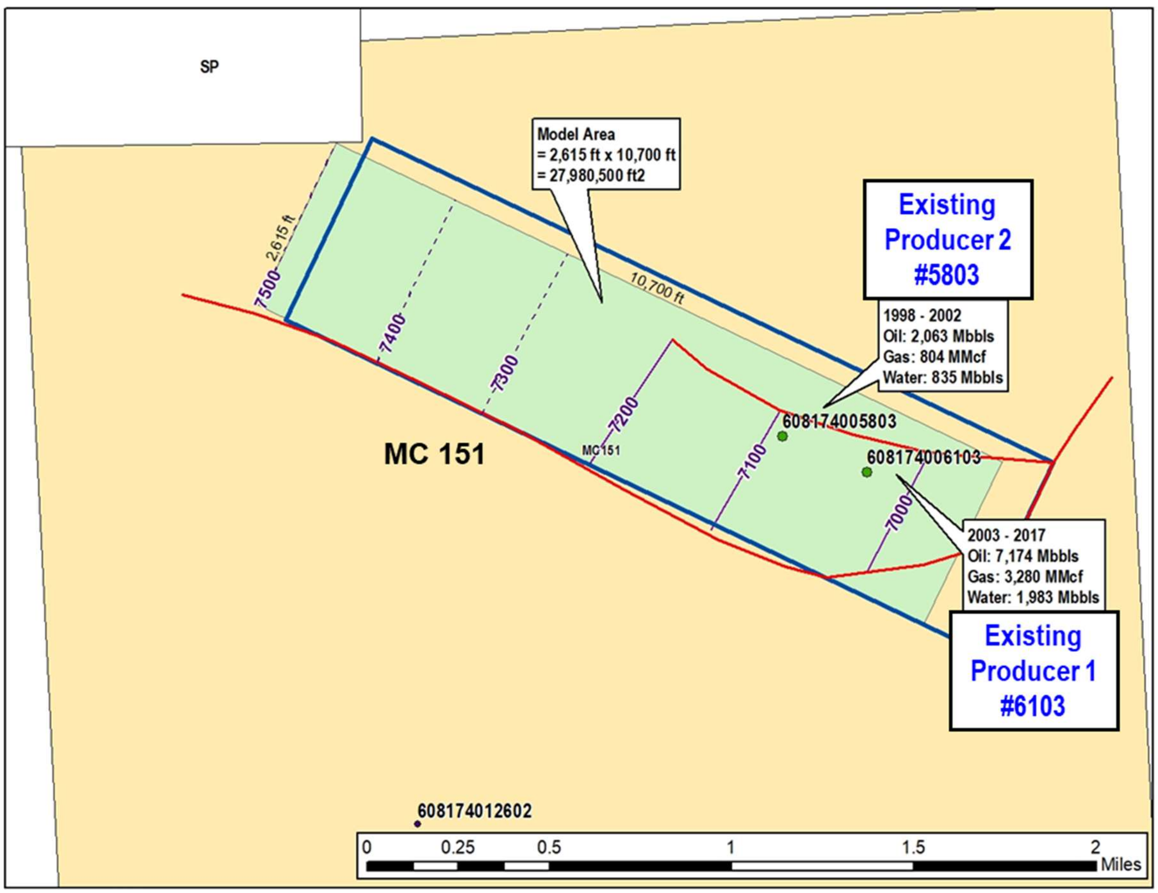
Source: Bureau of Ocean Energy Management (BOEM) data, 2018

3 Cognac Oil Field Northeast Fault Block J Sand

The reservoir modeling addresses the J Sand in the Northeast (NE) Fault Block of the Cognac oil field in MC 151. A down structure aquifer established the oil-water contact at 7,400 ft below sea level with the top of the salt dome providing closure to the reservoir. [6]

The NE Fault Block in MC 151 contains two oil producing wells—Well #5803 and Well #6103—producing from a fault bounded area of about 384 acres. Exhibit 3-1 provides a simplified representation of the NE Fault Block, including its structure, the location of the bounding faults, and the location of the two producing wells. [7]

Exhibit 3-1. Cognac oil field NE Fault Block outline



Source: Used with permission from Advanced Resources International [7]

The key volumetric and reservoir properties for the Cognac oil field NE Fault Block J Sand used for reservoir simulation are provided in Exhibit 3-2.

Exhibit 3-2. Reservoir properties, Cognac oil field NE Fault Block J Sand

Property	Value
Accessible Oil Area (acres)	384
Porosity (%)	32
Permeability (mD)	794
Net Pay (ft)	42
Oil Gravity (°API)	34.6
Swi	0.27
Boi (rb/stb)	1.21
OOIP (MMbbl)	24.2
Initial Pressure (at 8,297 ft) (psia)	4,412
Initial Reservoir Temperature (°F)	130

Based on the reservoir properties given in Exhibit 3-2, the OOIP for the Cognac oil field NE Fault Block J Sand is estimated at 24.2 MMbbl, as calculated below:

OOIP = (A * F) *7,758 (Ø * Soi/Boi)

= (384 * 42) * 7,758 B/AF (0.32 * 0.73/1.21)

= (16,128 AF) * (1,498 B/AF)

= 24.2 MMbbl

In the OOIP equation above, A is the accessible oil area, F is the average payzone net thickness, Soi is the initial oil saturation, and ϕ is reservoir porosity. Oil production from the Cognac oil field NE Fault Block J Sand has declined rapidly, from a peak of 4,000 bbl/d in 2004, to 1,390 bbl/d in 2016 and further to 1,250 bbl/d in mid-2017. As of mid-2017, the NE Fault Block J Sand has produced 9.25 MMbbl of oil, equal to 38 percent of OOIP. Exhibit 3-3 provides the annual oil production history of the NE Fault Block J Sand from inception in mid-1998 to mid-2017. [8]

Exhibit 3-3. Annual oil production, Cognac oil field NE Fault Block J Sand

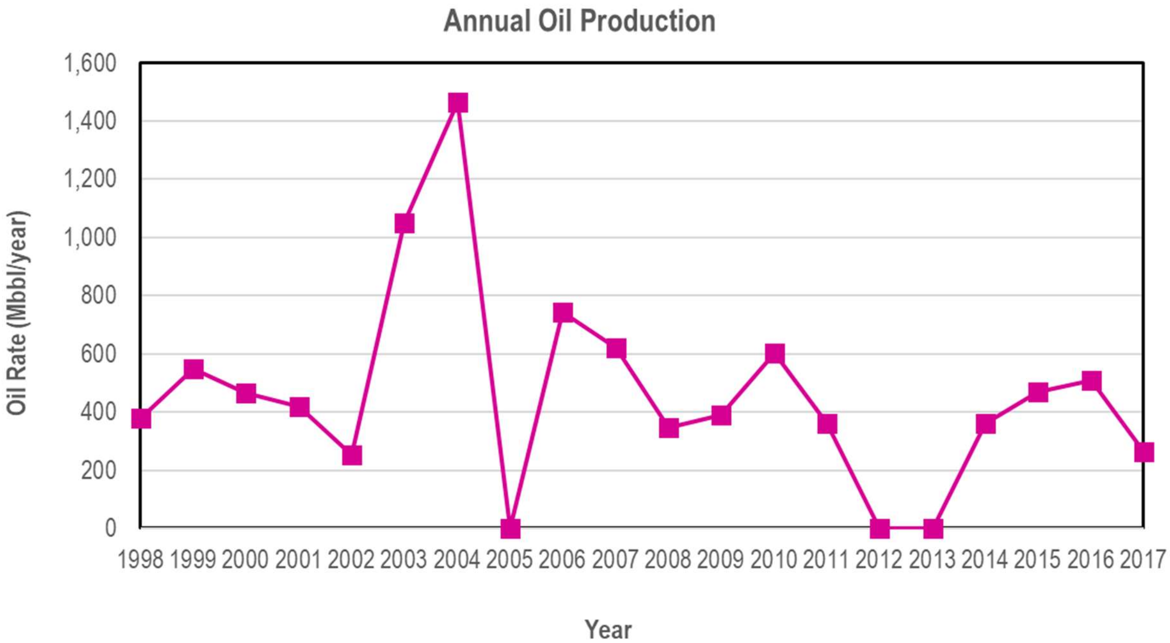


Exhibit 3-4 provides the cumulative oil production history of the Cognac oil field NE Fault Block J Sand from inception in 1998 to end of primary depletion in mid-2017, equaling 9.25 MMbbl. [8]

Exhibit 3-4. Cumulative oil production, Cognac oil field NE Fault Block J Sand

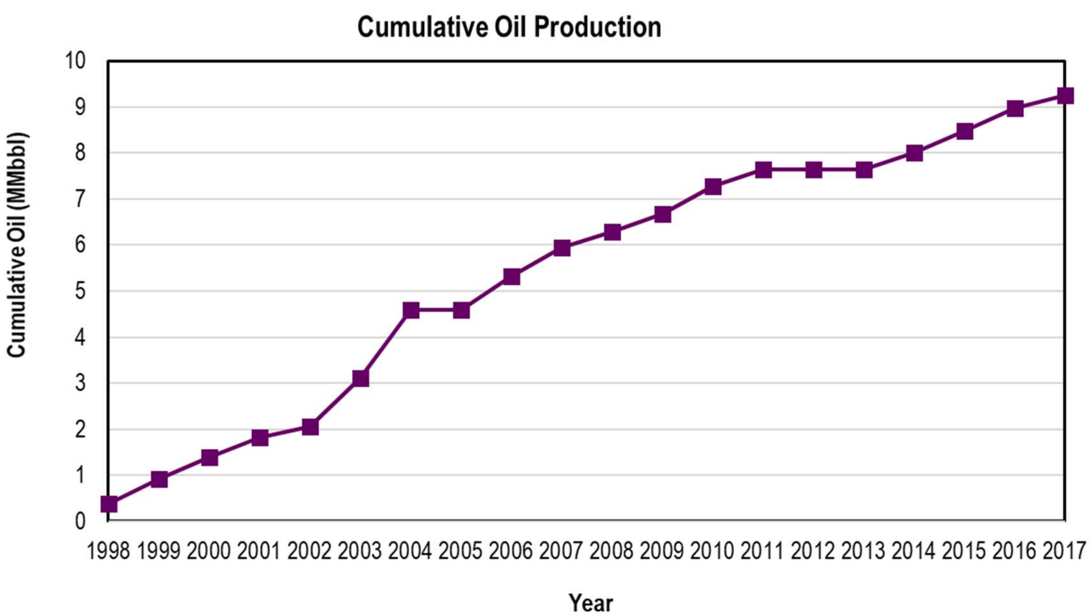


Exhibit 3-5 and Exhibit 3-6 provide the annual and cumulative water production for the Cognac oil field NE Fault Block J Sand from inception to end of primary depletion in mid-2017. [8] Total water production is about 2.7 MMbbl.

Exhibit 3-5. Annual water production, Cognac oil field NE Fault Block J Sand

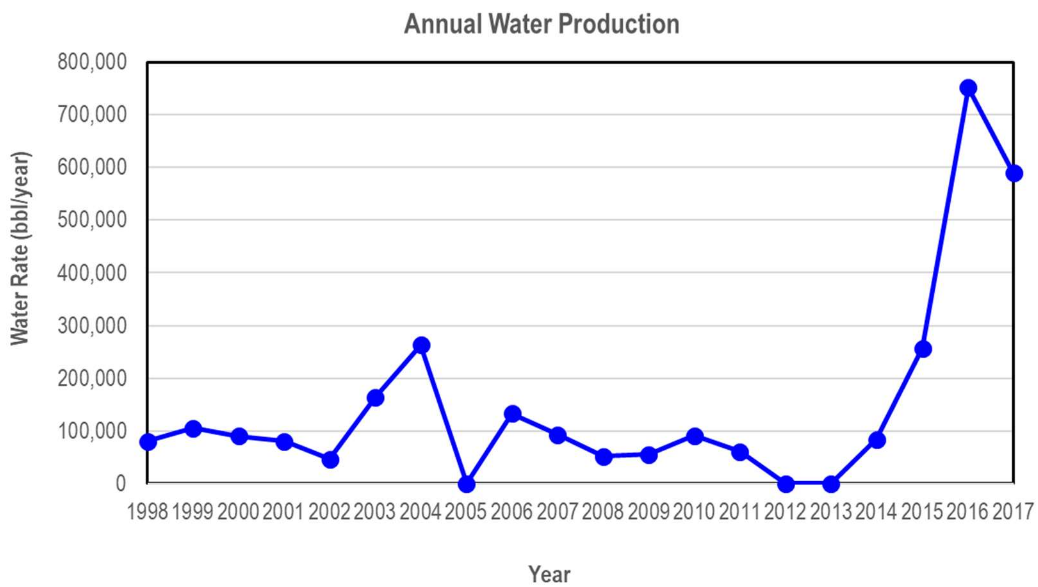


Exhibit 3-6. Cumulative water production, Cognac oil field NE Fault Block J Sand

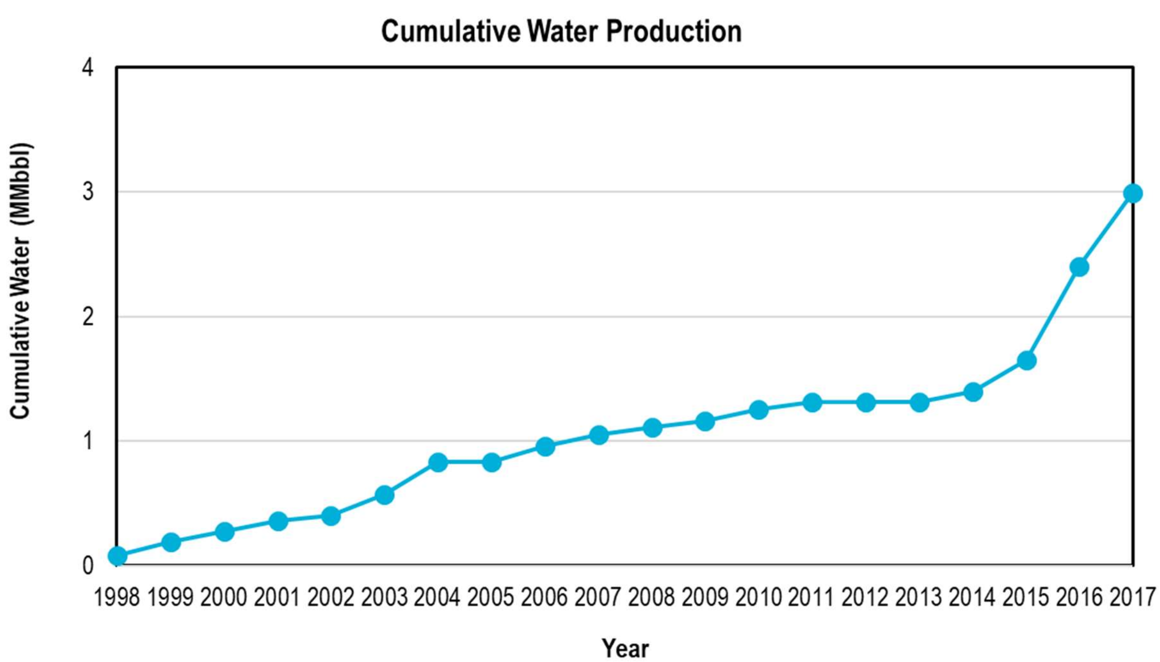


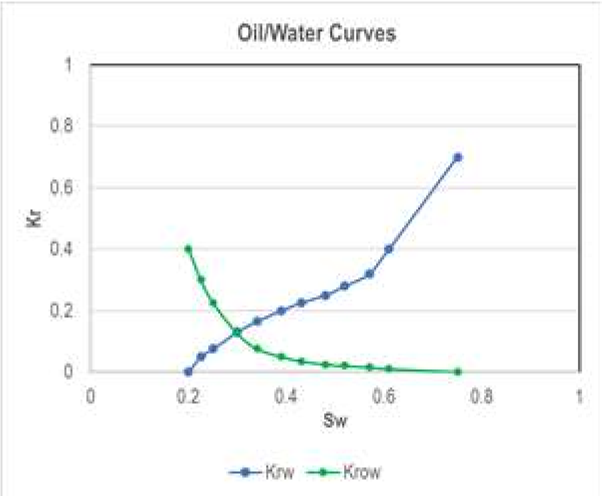
Exhibit 3-7 provides the hydrocarbon composition for the 35o American Petroleum Institute (API) gravity in the Cognac oil field NE Fault Block J Sand.

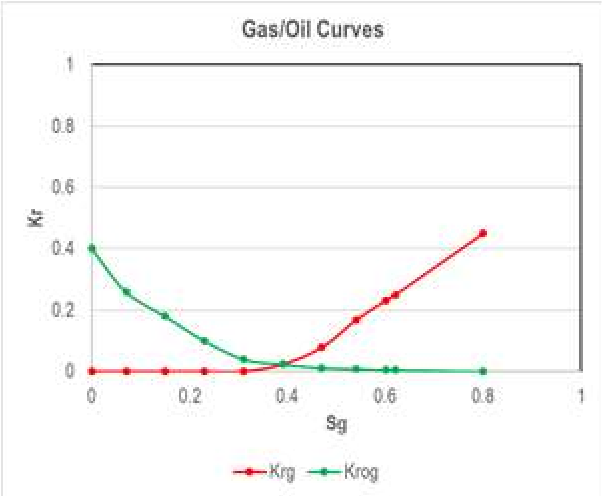
Exhibit 3-7. Oil composition Cognac oil field NE Fault Block J Sand

Component	Mole Fraction
C1	0.36
C2	0.02
C3	0.01
C4	0.04
C5	0.09
C6	0.07
C7-13	0.22
C14-20	0.08
C21-28	0.05
C29+	0.06

Exhibit 3-8 provides the relative permeability curves for oil/water and gas/oil used for history matching the Cognac oil field NE Fault Block J Sand and produced fluids.

Exhibit 3-8. Relative permeability for oil/water and gas/oil, Cognac oil field NE Fault Block J Sand





4 Reservoir Model for the Cognac Oil Field NE Fault Block J Sand

This section describes the reservoir model, which includes key reservoir properties such as volumetric data and oil composition, for the Cognac oil field NE Fault Block J Sand. Also, this section discusses calibration of the reservoir model.

4.1 Constructing the Reservoir Model

The reservoir model for the surface of the Cognac oil field NE Fault Block J Sand contains 702 grid blocks (54 x 13) each having a dimension of 200 ft in the X and Y directives, providing a total area of 645 acres. Excluding the aquifer grid blocks and the grid blocks outside the two bounding faults leave about 55 percent of the grid block for the oil area inside the faults, providing an area of 384 acres. The vertical dimension of the J Sand is represented by four layers, each having a thickness of 10.5 ft to model the 42 ft of net pay of the J Sand. Exhibit 4-1 and Exhibit 4-2 illustrate the structure, depth, areal extent, and thickness of the reservoir model constructed for the Cognac oil field NE Fault Block J Sand. [8]

Exhibit 4-1. Cognac oil field NE Fault Block J Sand 3-D model, side view

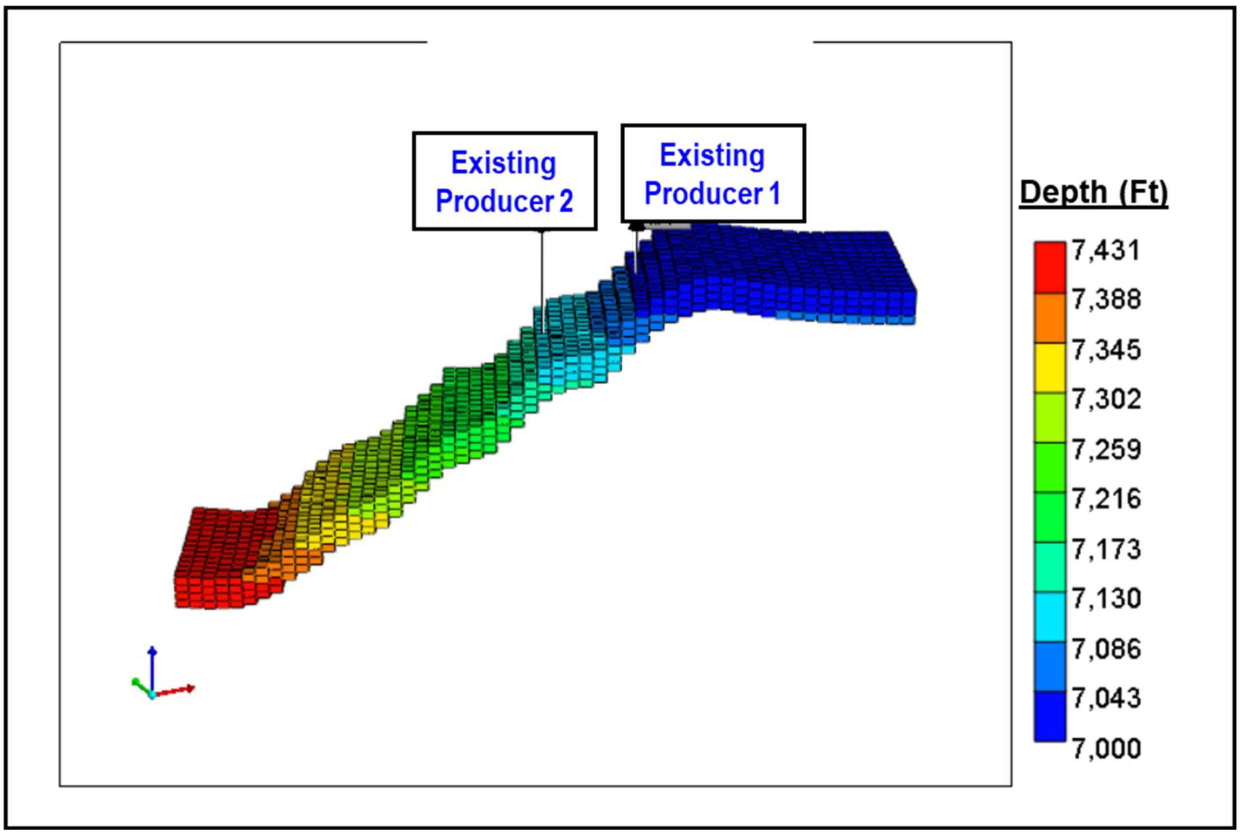
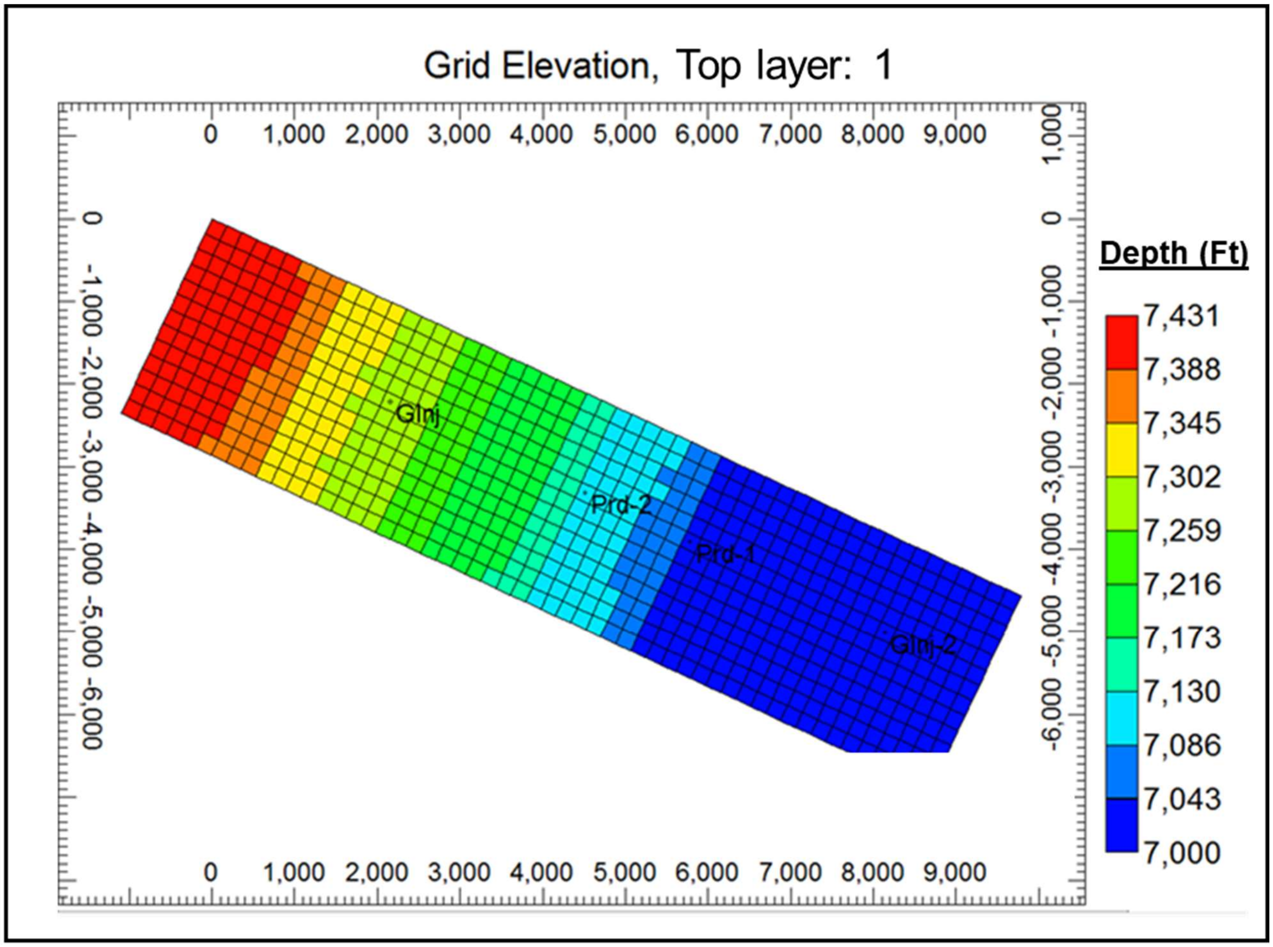


Exhibit 4-2. Cognac oil field NE Fault Block J Sand 2-D model, top view



4.2 Calibrating the Reservoir Model

To calibrate the Cognac oil field NE Fault Block J Sand's reservoir properties, a history match of primary oil, water, and gas production as reported for the J Sand from mid-1998 through mid-2017 was performed. The fluid production values were history matched using GEM, the J Sand structure, and the volumetric and reservoir properties provided in Section 3. Given the presence of an aquifer below the oil saturated area and the complex production history of the NE Fault Block, reaching an acceptable history match for the J Sand represented a significant achievement (Exhibit 4-3). [8] An important output of the history match was the estimate of J Sand reservoir pressure at the end of primary production, essential for designing injection volumes and schedules for the proposed CO_2 flood in the NE Fault Block (Exhibit 4-4).

Exhibit 4-3. History match of cumulative fluid production, Cognac oil field NE Fault Block J Sand

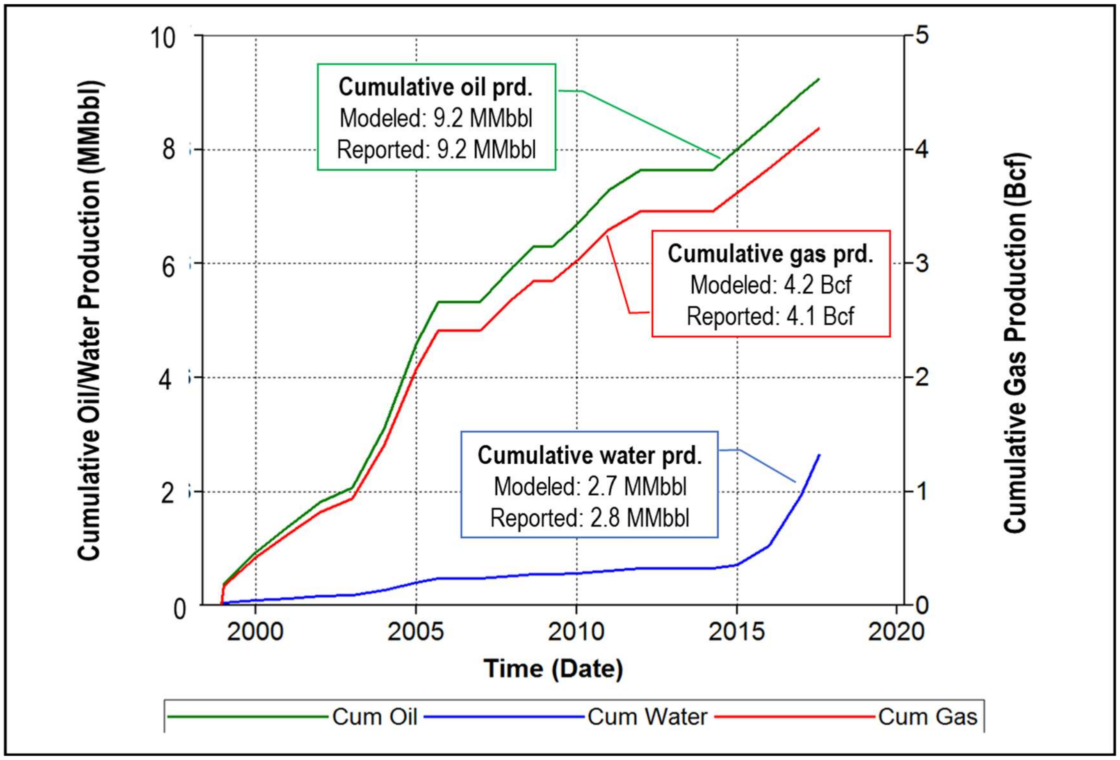
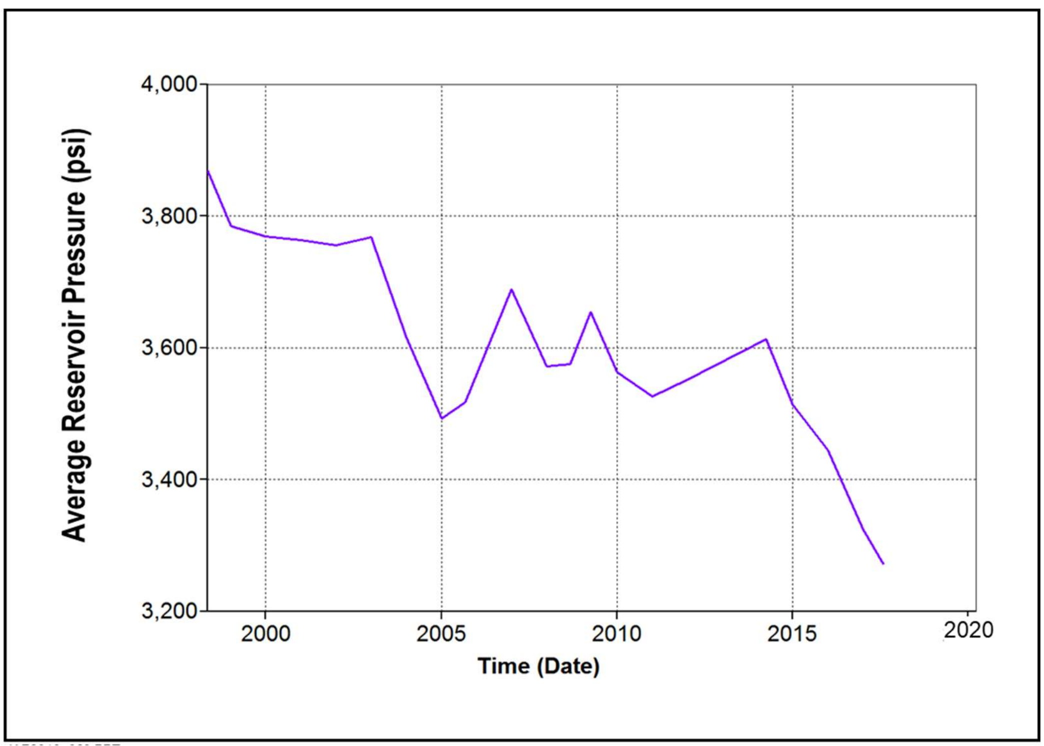
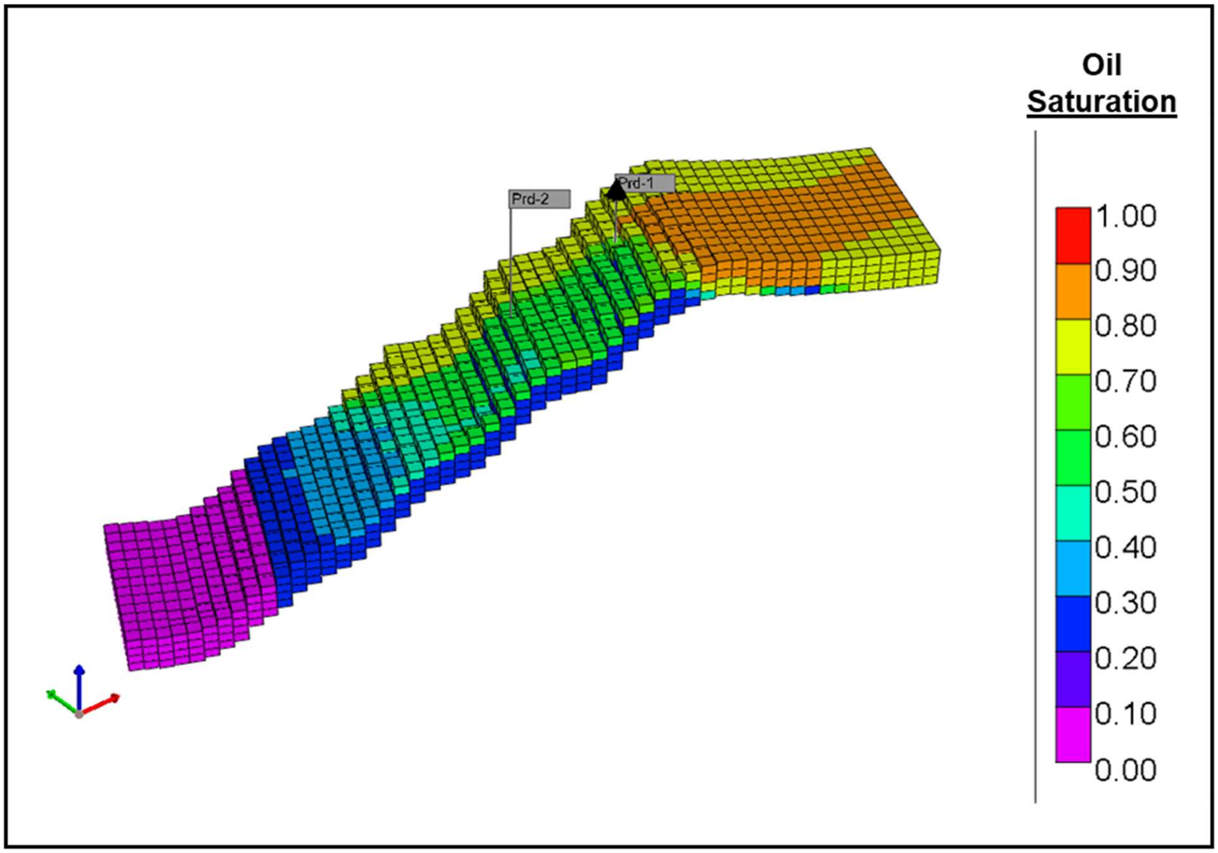


Exhibit 4-4. Reservoir pressure from history match of fluid production, Cognac oil field NE Fault Block J Sand



An equally important output of the history match was establishing the location of the oil remaining in the Cognac oil field NE Fault Block J Sand reservoir at the end of primary production (Exhibit 4-5). This information helped establish the optimum location for the new CO_2 injection well for modeling the CO_2 flood in the NE Fault Block. The initial oil saturation in the oil zone before primary production was estimated at 0.73 with a formation volume factor of 1.21.

Exhibit 4-5. Oil saturation at end of primary production, Cognac oil field NE Fault Block J Sand



5 GEM Modeling of the Performance of the CO_2 Flood, Cognac Oil Field NE Fault Block J Sand

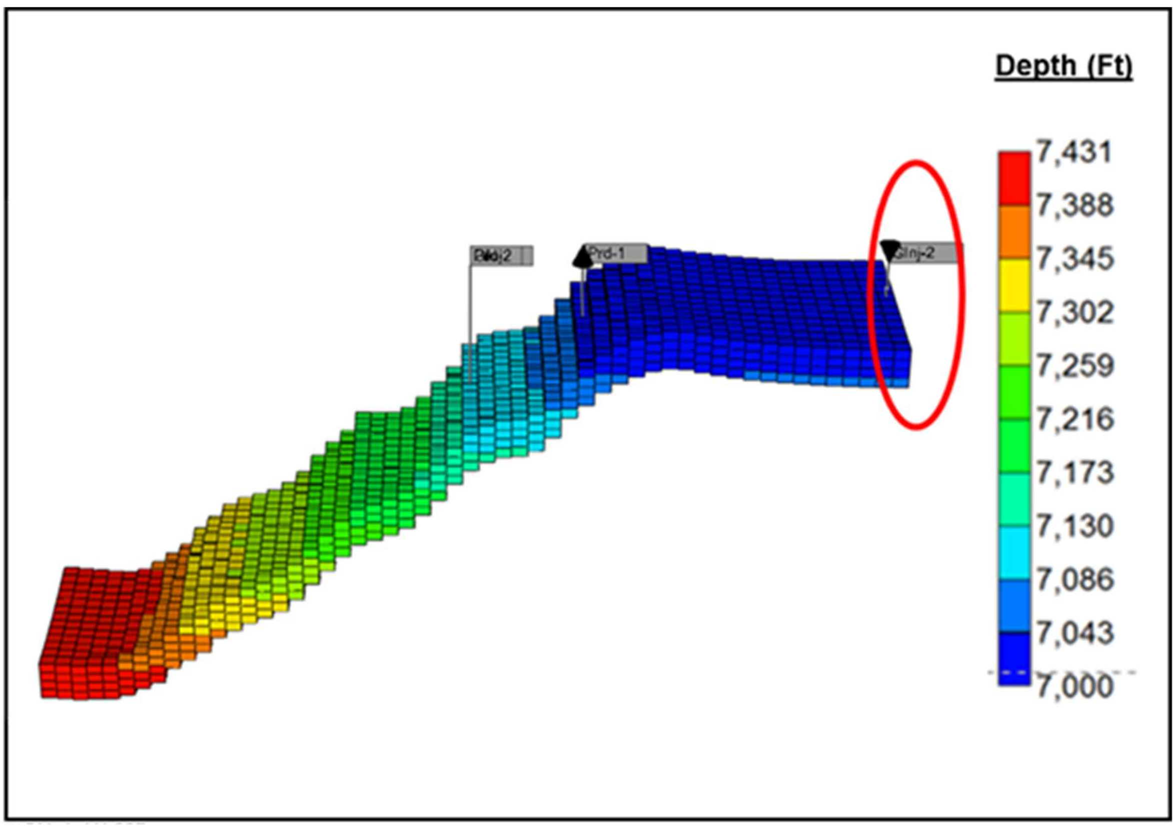
The reservoir model constructed for the Cognac oil field NE Fault Block J Sand (Section 4) was placed into GEM to evaluate the expected performance of the CO_2 flood.

5.1 CO_2 Flood Design

Given the structural dip of the formation, its high permeability, the strong bottom waterdrive, and the location of the remaining oil after primary recovery, the design of the CO_2 flood in the Cognac oil field NE Fault Block J Sand was as follows:

- Drill an updip CO_2 injection well on the crest of the fault block (Exhibit 5-1)
- Inject continuous CO_2 at a rate of 24 MMcfd into the J Sand for 10 years and 20 years
- Shut in the producing wells for 12 months to raise reservoir pressure open wells; operate the CO_2 flood using a bottom hole production well back pressure of 3,000 psi
- Initially produce from updip production well (Prd #1) until CO_2 breakthrough; then, shut in updip production well and open downdip production well (Prd #2) and produce until the end of the CO_2 flood

Exhibit 5-1. Structure and well locations for CO_2 flood, Cognac oil field NE Fault Block J Sand

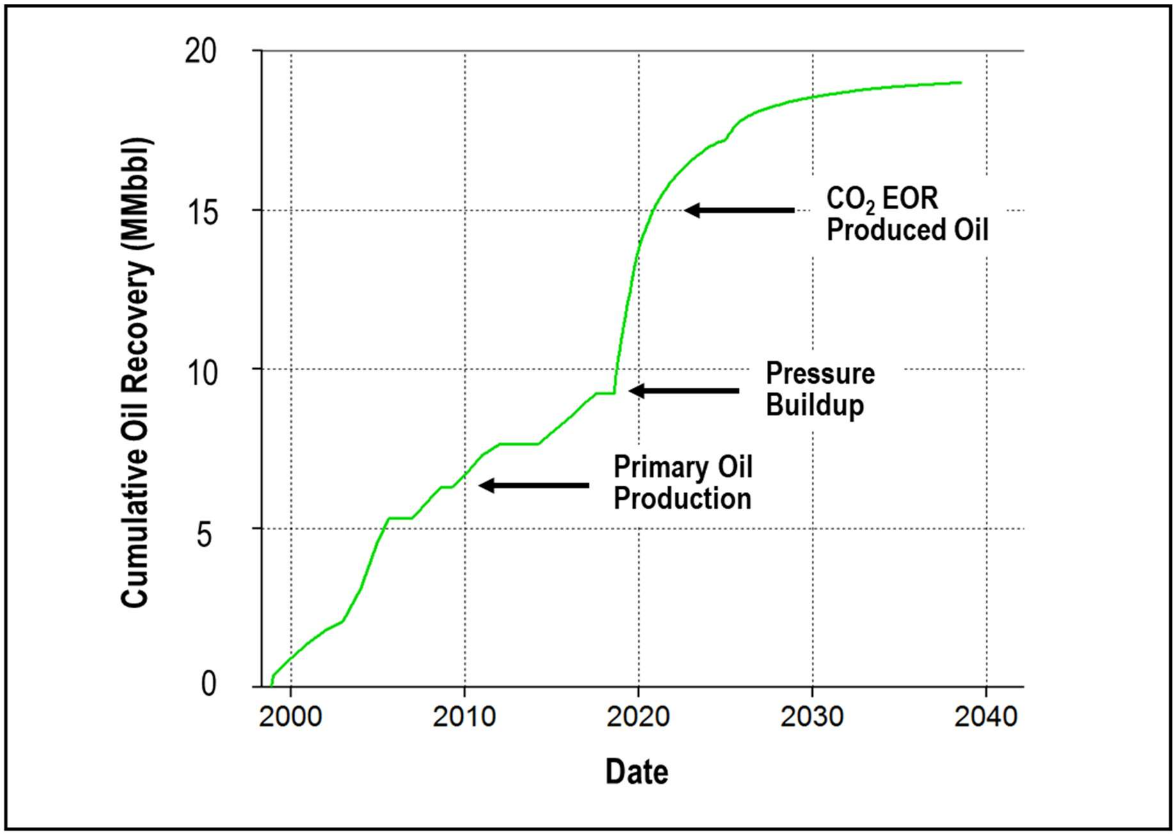


5.2 CALCULATED OIL RECOVERY

GEM modeling of the CO_2 flood in the Cognac oil field NE Fault Block J Sand provided the following volumes of incremental oil recovery (beyond primary) (Exhibit 5-2). [8]

- 8.2 MMbbl of incremental oil recovery following 10 years of CO_2 injection, equal to 34 percent of OOIP
- 8.8 MMbbl of incremental oil recovery following 20 years of CO_2 injection, equal to 36 percent of OOIP

Exhibit 5-2. Cumulative oil recovery, primary recovery, and CO_2 flood, Cognac oil field NE Fault Block J Sand



5.3 CALCULATED CO_2 INJECTION, PRODUCTION, AND STORAGE

GEM modeling of the CO_2 flood in the Cognac oil field NE Fault Block J Sand also provided the following data on CO_2 injection, production, and storage (Exhibit 5-3).

- CO_2 injection of 89 Bcf, with CO_2 production of 52 Bcf and CO_2 storage of 37 Bcf for the 10-year CO_2 flood
- CO_2 injection of 182 Bcf, with CO_2 production of 143 Bcf and CO_2 storage of 39 Bcf for the 20-year CO_2 flood

Exhibit 5-3. Cumulative CO_2 injection and production, Cognac oil field NE Fault Block J Sand

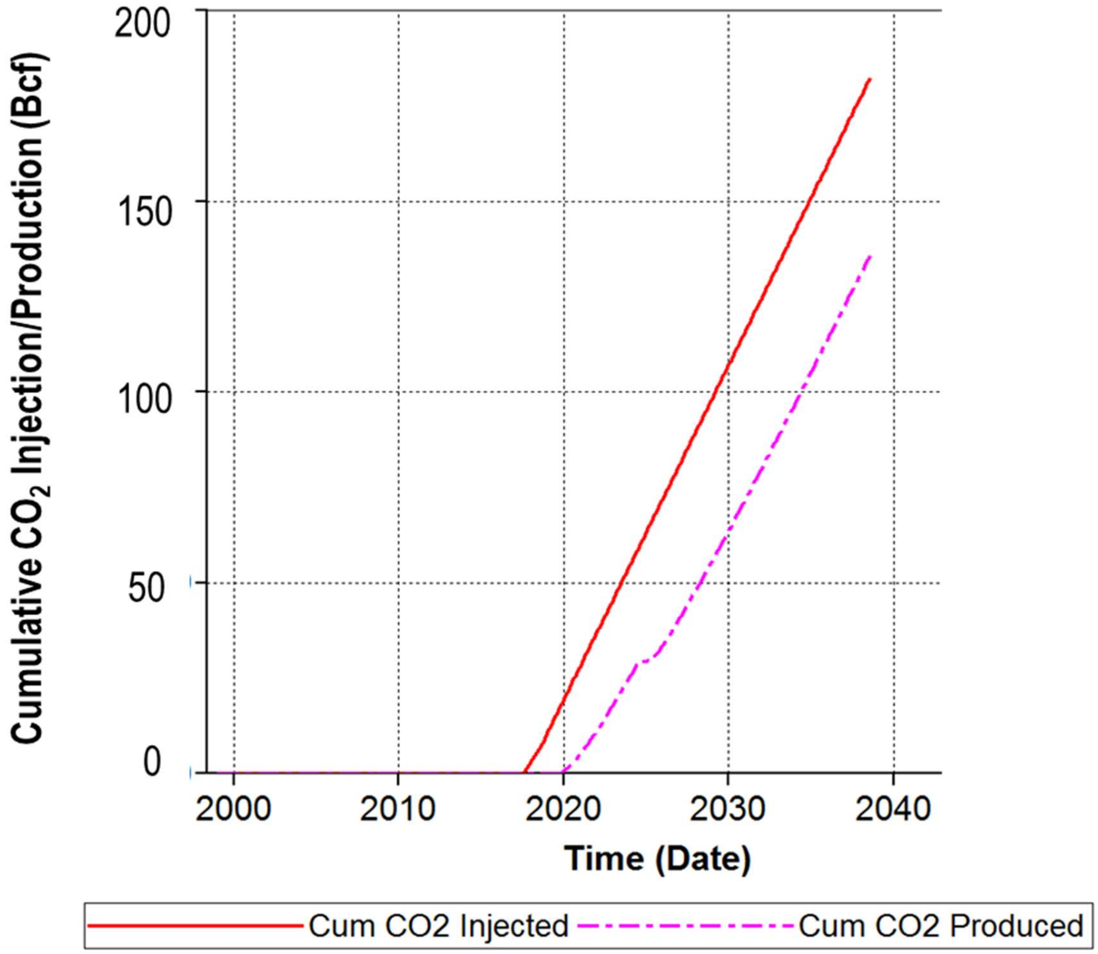


Exhibit 5-4 provides the annual and cumulative data for oil production and the cumulative data for CO_2 injection and production from the Cognac oil field NE Fault Block J Sand. For the 10-year CO_2 flood, the key CO_2 to oil ratios were 10.9 thousand cubic feet per barrel (Mcf/bbl) (gross) and 4.5 Mcf/bbl (net).

Exhibit 5-4. Oil production, CO_2 injection, and CO_2 production; GEM modeling of the CO_2 flood, Cognac oil field NE Fault Block J Sand

Year	Oil Production		Cumulative CO_2	
	Annual (bbl/d)	Cumulative (MMbbl)	Injection (Bcf)	Production (Bcf)
2018	4,700	1.7	10.6	0.0
2019	6,800	4.2	19.3	1.7
2020	2,920	5.3	28.1	4.2
2021	2,660	6.2	36.9	8.3
2022	1,650	6.8	45.6	14.6
2023	1,160	7.3	54.4	21.5
2024	850	7.6	63.2	28.8
2025	710	7.8	71.9	36.3
2026	560	8.0	80.7	44.2
2025	390	8.2	89.5	52.3

6 Modeling the Performance of the Cognac Oil Field, NE Fault Block J Sand CO_2 Flood with CO_2 Prophet Model

In parallel with GEM, the CO_2 Prophet Model was used to evaluate the expected performance of the CO_2 flood in the Cognac oil field NE Fault Block J Sand using the volumetric and reservoir properties and data provided in Section 3. Exhibit 6-1 lists the key volumetric and reservoir properties data for the Cognac oil field NE Fault Block J Sand, and Exhibit 6-2 and Exhibit 6-3 are the input data sheets for modeling the CO_2 flood in the Cognac oil field NE Fault Block J Sand using the CO_2 Prophet Model.

To capture the heterogeneity of the J Sand, a Dykstra-Parsons (DP) coefficient of 0.75 (the minimum value used in CO_2 Prophet modeling) was used. The impact of using a more favorable DP coefficient of 0.5 that would represent a highly uniform reservoir sand was also examined.[a]

[a] The DP coefficient is used by the reservoir engineering community to define the heterogeneity of a reservoir, with a low value (0.5 or so) reflecting low heterogeneity and a high value (0.9 or so) reflecting high heterogeneity. A full-scale, compositional reservoir model typically assigns different permeability values to discrete units of net pay (the vertical stack of grid blocks) to capture the reservoir heterogeneity.

Exhibit 6-1. Volumetric and reservoir properties, Cognac oil field NE Fault Block J Sand

Basin Name	**Deep Water**	**Area:**	**Offshore**
State	**LA**		To change Basin, click on cell above
Field Name	**MC194 Cognac**	**Reservoir No.**	**24231**
		Manual	**24231**
Reservoir	**MC194J Sand/NE Fault Block**	**Total Reservoirs**	**24188**

Reservoir Parameters:

Area (A)	**385**
Net Pay (ft)	**42.0**
Depth (ft)	**9,319**
Lithology	**1**
Dip (°)	**0**
Gas/Oil Ratio (Mcf/Bbl)	**2,724**
Salinity (ppm)	**100,000**
Gas specific Gravity	**0.60**
Historical Well Spacing (Acres)	**-1**
Current Pattern Acreage (Acres)	**384**
Permeability (mD)	**794**
Porosity (%)	**32.0%**
Reservoir Temp (deg F)	**130**
Initial Pressure (psi)	**4,412**
Pressure (psi)	**-1**
B_{oi}	**1.21**
B_o @ S_o, swept	**1.21**
S_{oi}	**0.73**
S_{or}	**0.45**
S_{wi}	**0.27**
S_w	**0.55**
API Gravity	**34.6**
Viscosity (cp)	**0.31**
Dykstra-Parsons	**0.75**

Miscibility:

C5+ Oil Composition	194.5
Min Required Miscibility Press(psig)	1701.5
Depth > 3000 feet	1
API Gravity >= 17.5	1
Pr > MMP	0
Flood Type	Miscible

Oil Production

Producing Wells (active)	**1**
Producing Wells (shut-in)	**0**
2014 Production (MMbbl)	**0.00**
2014 P/S Production (MMbbl)	**0.00**
Cum Oil Production (MMbbl)	**9.2**
EOY 2014 Oil Reserves (MMbbl)	**0.0**
Water Cut	**0.0%**

Water Production

2014 Water Production (Mbbl)	**0.00**
Daily Water (Mbbl/d)	**0.00**

Injection

Injection Wells (active)	**1**
Injection Wells (shut-in)	**0**
2008 Water Injection (MMbbl)	**0.00**
Daily Injection - Field (Mbbl/d)	**0.00**
Cum Injection (MMbbl)	**0.00**
Daily Inj per Well (Bbl/d)	**0.00**

EOR

Type	**0**
2014 EOR Production (MMbbl)	**0.00**
Cum EOR Production (MMbbl)	**0.00**
EOR 2014 Reserves (MMbbl)	**0.00**
Ultimate Recoverery (MMbbl)	**0.00**

OGJ Data

2014 Enhanced Production (B/d)	**0.00**
2014 Total Production (B/d)	**0.00**
Project Acreage	**0**
Scope	**0**
# Projects	**0**

Volumes

OOIP (MMbl)	**24.2**
Cum P/S Oil (MMbl)	**9.2**
EOY 2014 P/S Reserves (MMbl)	**0.0**
Ultimate P/S Recovery (MMbl)	**9.2**
Remaining (MMbl)	**15.0**
Ultimate P/S Recovered (%)	**38%**
P/S Sweep Efficiency (%)	**99%**

OOIP Volume Check

Reservoir Volume (AF)	**16,158**
Bbl/AF	**1,498**
OOIP Check (MMbl)	**24.2**

SROIP Volume Check

Reservoir Volume (AF)	**16,158**
Swept Zone Bbl/AF	**923**
SROIP Check (MMbl)	**14.9**

ROIP Volume Check

ROIP Check (MMbl)	**15.0**

Exhibit 6-2. Input data sheet, CO_2 Prophet modeling of Cognac oil field NE Fault Block J Sand (DP = 0.75)

```
'COGNAC 384 Ac Input'
'********** 'WELL AND PATTERN DATA ********'
'PATTERN'
'LD'
'NWELLS       NOINJ'
2,             1
'WELLS        WELLY         WELLQ'
0,            0,             1
1,            1,            -1
'NBNDPT'
 5
'BOUNDX       BOUNDY'
0,             0
0,             1
1,             1
1,             0
0,             0
'*************  PROGRAM CONTROLS  ********'
'LWGEN        OUTTIM'
'N',           1
'**** RELATIVE PERMEABILITY PARAMETERS ***'
'SORW         SORG          SORM'
0.20,          0.3,           0.1
'SGR          SSR'
0.3,          0.3
'SWC          SWIR'
0.3,           0.3
'KROCW        KWRO          KRSMAX        KRGCW'
0.8,          0.2,          0.4,           0.45
'EXPOW        EXPW          EXPS          EXPG          EXPOG'
2,            2,            2,            2,            2
'KRMSEL       W'
1,             0.999
'***************  FLUID DATA  ************'
'VISO         VISW'         CO2SOL 0 REDFAC 0.10 CO2INJ
0.31,         0.62
'BO           RS            API           SALN          GSG'
1.21,         2724,         34.6,         100000,       0.64
'************** RESERVOIR DATA ***********'
'TRES         P             MMP'
130,          4412,        1702
'DPCOEF       PERMAV        THICK         POROS         NLAYERS'
0.75,         794,          42,           0.32,         10
'SOINIT       SGINIT        SWINIT'
0.45,          0,            0.55
'AREA         XKVH'
16727040,       0.5
'********** INJECTION PARAMETERS *********'
'NTIMES       WAGTAG'
1,            'T'
'HCPVI        WTRRAT        SOLRAT        TMORVL'
1.24,          10000,         24,           0.0
```

Exhibit 6-3. Input data sheet, CO_2 Prophet modeling of Cognac oil field NE Fault Block J Sand (DP = 0.5)

```
'COGNAC 384 Ac Input'
'********** 'WELL AND PATTERN DATA ********'
'PATTERN'
'LD'
'NWELLS       NOINJ'
2,             1
'WELLS        WELLY         WELLQ'
0,            0,             1
1,            1,            -1
'NBNDPT'
 5
'BOUNDX       BOUNDY'
0,             0
0,             1
1,             1
1,             0
0,             0
'*************  PROGRAM CONTROLS  ********'
'LWGEN        OUTTIM'
'N',           1
'**** RELATIVE PERMEABILITY PARAMETERS ***'
'SORW         SORG          SORM'
0.20,          0.3,           0.1
'SGR          SSR'
0.3,          0.3
'SWC          SWIR'
0.3,           0.3
'KROCW        KWRO          KRSMAX        KRGCW'
0.8,          0.2,          0.4,           0.45
'EXPOW        EXPW          EXPS          EXPG          EXPOG'
2,            2,            2,            2,            2
'KRMSEL       W'
1,             0.999
'***************  FLUID DATA  ************'
'VISO         VISW'         CO2SOL 0 REDFAC 0.10 CO2INJ
0.31,         0.62
'BO           RS            API           SALN          GSG'
1.21,         2724,         34.6,         100000,       0.64
'************** RESERVOIR DATA ***********'
'TRES         P             MMP'
130,          4412,        1702
'DPCOEF       PERMAV        THICK         POROS         NLAYERS'
0.50,         794,          42,           0.32,         10
'SOINIT       SGINIT        SWINIT'
0.45,          0,            0.55
'AREA         XKVH'
16727040,       0.5
'********** INJECTION PARAMETERS *********'
'NTIMES       WAGTAG'
1,            'T'
'HCPVI        WTRRAT        SOLRAT        TMORVL'
1.04,          10000,         24,           0.0
```

6.1 CO_2 FLOOD DESIGN

The more complicated geologic structural setting and well locations of the Cognac oil field NE Fault Block J Sand were modeled with the CO_2 Prophet Model using the following features:

- Drill a CO_2 producer and operate the CO_2 flood in a two well line drive configuration
- Inject continuous CO_2 at a rate of 24 MMcfd for 10 years, reaching a cumulative injection of CO_2 of 88 Bcf equal to CO_2 injected in GEM (a hydrocarbon pore volume of 1.2)

6.2 CALCULATED OIL RECOVERY

CO_2 Prophet modeling of the CO_2 flood in the Cognac oil field NE Fault Block J Sand with a DP coefficient of 0.75 provided incremental oil recovery (beyond primary) of 6.3 MMbbl for a 10-year CO_2 flood. CO_2 Prophet modeling of the CO_2 flood in the Cognac oil field NE Fault Block J Sand with a DP coefficient of 0.5 provided incremental oil recovery (beyond primary) of 8.7 MMbbl for a 10-year CO_2 flood.

6.3 CALCULATED CO_2 INJECTION, PRODUCTION, AND STORAGE

CO_2 Prophet modeling of the CO_2 flood in the Cognac oil field NE Fault Block J Sand provided the following data for CO_2 injection, production, and storage for a 10-year CO_2 flood.

- For the DP = 0.75 case, CO_2 injection of 88 Bcf, CO_2 production of 54 Bcf, and CO_2 storage of 34 Bcf for a 10-year CO_2 flood. For the DP = 0.75 case CO_2 flood, the key CO_2 to oil ratios were 13.9 Mcf/bbl (gross) and 5.1 Mcf/bbl (net).
- For the DP = 0.5 case, CO_2 injection of 88 Bcf, CO_2 production of 46 Bcf, and CO_2 storage of 42 Bcf for a 10-year CO_2 flood. For the DP = 0.5 case CO_2 flood, the key CO_2 to oil ratios were 10.1 Mcf/bbl (gross) and 4.9 Mcf/bbl (net).

Exhibit 6-4 (for DP = 0.75) and Exhibit 6-5 (for DP = 0.5) provide the data for oil production, CO_2 injection, and CO_2 production of the performance of the CO_2 flood in the Cognac oil field NE Fault Block J Sand using the CO_2 Prophet Model.

Exhibit 6-4. Oil production, CO_2 injection, and CO_2 production; CO_2 Prophet modeling of the CO_2 flood, Cognac oil field NE Fault Block J Sand (DP = 0.75)

Year	Oil Production		Cumulative CO_2	
	Annual (bbl/d)	Cumulative (MMbbl)	Injection (Bcf)	Production (Bcf)
2018	5,350	2.0	8.8	0.8
2019	3,110	3.1	17.5	4.4
2020	2,090	3.9	26.3	9.3
2021	1,570	4.4	35.1	14.9
2022	1,220	4.9	43.8	21.0
2023	1,020	5.2	52.6	27.4
2024	880	5.6	61.4	34.0
2025	780	5.8	70.1	40.7
2026	690	6.1	78.9	47.5
2025	620	6.3	87.7	54.4

Exhibit 6-5. Oil production, CO_2 injection, and CO_2 production; CO_2 Prophet modeling of the CO_2 flood, Cognac oil field NE Fault Block J Sand (DP = 0.5)

Year	Oil Production		Cumulative CO_2	
	Annual (bbl/d)	Cumulative (MMbbl)	Injection (Bcf)	Production (Bcf)
2018	5,920	2.2	8.8	0.1
2019	4,680	3.9	17.5	1.7
2020	3,310	5.1	26.3	5.0
2021	2,460	6.0	35.1	9.4
2022	1,910	6.7	43.8	14.6
2023	1,540	7.2	52.6	20.2
2024	1,250	7.7	61.4	26.2
2025	1,030	8.1	70.1	32.5
2026	880	8.4	78.9	39.1
2025	760	8.7	87.7	45.7

7 Comparative Analysis of GEM and CO_2 Prophet Modeling of CO_2 Flood, Cognac Oil Field NE Fault Block J Sand

Based on the information provided in Section 5 and Section 6, it was found that the CO_2 Prophet Model was able to reasonably represent the performance of the CO_2 flood modeled using the more sophisticated GEM. Exhibit 7-1 provides a comparison of the results for the Cognac oil field NE Fault Block J Sand from the two reservoir models. The DP reservoir heterogeneity values of 0.5 to 0.75 used in the CO_2 Prophet Model provide results that bracket the performance of the CO_2 flood as calculated using GEM.

Exhibit 7-1. Comparative assessments of performance for the Cognac oil field NE Fault Block J Sand

Parameter	CO_2 Flood Performance GEM	CO_2 Flood Performance CO_2 Prophet Model	
		DP = 0.75	DP = 0.5
OOIP (MMbbl)	24.2	24.4	24.2
CO_2 Injection (Bcf)	89.5	87.7	87.7
CO_2 Production (Bcf)	52.3	55.7	45.3
CO_2 Storage (Bcf)	37.2	32.0	42.4
Cumulative Oil Recovery			
MMbbl	8.18	6.33	8.67
% of OOIP	33.8	26.2	35.8
CO_2/Oil Ratio (Mcf/bbl)			
Gross	10.9	13.9	10.1
Net	4.5	5.1	4.9

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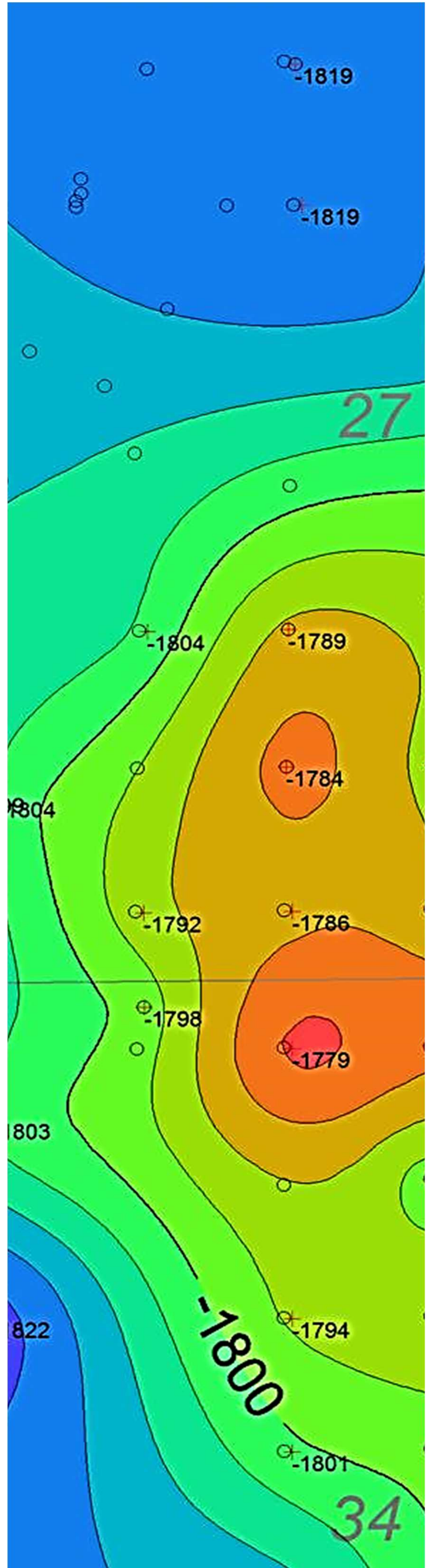

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